

You work in a modern, high-rise office building or an older building that has been recently refurbished. It's a typical energy-efficient building. The windows are sealed, the temperature and air flow are centrally regulated, the lights are fluorescent. Like most floors in the building, yours is dotted with the usual - and growing - complement of video display terminals (VDTs), photocopy machines and other office equipment. It's Friday and you're not feeling all that well: slight headache, scratchy eyes, a little irritable, generally listless. You notice, too, that you have trouble catching your breath. Nothing serious, of course. Only thing is, you didn't feel much better yesterday. Or the day before. In fact, you can't remember the last time you left the office feeling yourself. "Stress," you mutter, and go home for the weekend, promising to slow down a little. You feel fine until Monday, when your symptoms being anew and build up throughout the week.

Given today's highly competitive corporate environment, with its deadlines and productivity demands and its often less than ideal working conditions, the general malaise described above may, indeed, be symptomatic of on-the-job stress. It may also, however, be related to the office air you breathe.

Until fairly recently, indoor air quality was taken for granted. As long as the air outside was safe to breathe, the reasoning went, what could be wrong with the air inside? Plenty, it now appears. Doug Walkinshaw, co-ordinator of indoor air quality for the National Research Council, says that in addition to the kinds of minor, non-specific ailments mentioned above, contaminated indoor air can, in some circumstances, cause respiratory ailments as specific and severe as asthma and Legionnaire's disease. Walkinshaw stops short, however, of calling the quality of indoor air today a serious problem: its appearance as an issue is so recent, its symptoms often so subjective and its root causes so debatable that governments and scientists around the world are now just beginning to address the issue formally. He will say, though, that in a cold climate such as Canada's, where so many people spend so much time indoors, "problems associated with indoor air quality may have considerable impact throughout the country."

Concern over indoor air quality in non-industrial buildings increased in the early 1970s, about the same time that energy conservation measures were being introduced. To conserve energy, many building owners (including home owners) found ways to minimize the infiltration or uncontrolled leakage of outside air into buildings. At the same time, to save money, they also cut back on ventilation - the regulated flow of fresh air in buildings. These and other energy-efficiency measures are saving Canadians about \$5 billion a year in relation to pre-1973 expenditures on energy, according to data published by the Canadian National Energy Board. Unfortunately, the resulting energy-efficient, or "tight" buildings, as they have become known, can contribute to the buildup of a multitude of dangerous contaminants and bacteria - everything from radiation from VDTs and ozone from photocopyers to styrene gas from carpets, formaldehyde from furniture and, of course, tobacco smoke. "A chemical soup," is how some experts describe today's office environment.

## SOME INDOOR AIR POLLUTANTS AND THEIR SOURCES

Contaminant	Possible Sources
Carbon Monoxide	Gas and Other Fuel Burning Equipment
Nitrogen Oxides	Gas Combustion Equipment
Formaldehyde	Insulation, Furnishings, Plastics, Office Materials
Ozone	Photocopiers, Electronic Air Cleaners
Radon and Progeny	Building Materials and Ground Waters
Organic Vapours	Cleaning and Office Materials, Plastics, Aerosol Sprays, Restaurants, Human body odours
Carbon Dioxide	Human respiration, Fuel Equipment and Smoking
Total Particulates	Smoking, paper and floor dust, Cooking, Outdoor particulates
Asbestos	Insulation
Viable Organisms	Humidifiers, Humans, Animals

Source: Sullivan, J.L., "Air Pollutants in the Office" presented at a Conference on "Environmental Concerns in Offices and Homes" London, Ontario September 24 & 25, 1984.

John Chandler, a senior engineer with the Concord Scientific Corporation of Toronto (an environmental research company specializing in air-quality testing), says that aside from the severity of health risks, chronic exposure to poor-quality air "will have a serious effect on the workers' ability to do their job." And Karl Linton, a systems consultant in the mechanical engineering department of the Ontario Ministry of Government Services, says that the reduction in employee's efficiency resulting from poor-air quality may cost more than is saved by today's - and tomorrow's - tight buildings.

Dealing with indoor air quality, however, is a far more complex matter than simply addressing the energy efficiency of buildings. According to Chandler, "there are also building maintenance concerns, people concerns and construction and office material concerns." Taken together, they present a range of air-quality and general office-environment problems that have become lumped together and labelled the "Sick-Building Syndrome."

The following cases illustrate different aspects of the Sick-Building Syndrome. They also offer a variety of solutions to poor-quality indoor air and its associated ills. Although the experts may still be groping for scientific explanations, they have, nonetheless, developed a range of measures - many of them common-sense cures - that will alleviate the vast majority of symptoms of Sick-Building Syndrome. What's more, these measures work without having to undo a decade of dedicated energy conservation.

## THE CLASSIC SICK BUILDING



Federal government employees in Les Terrasses, a modern office and hotel complex, prompted a series of studies and adjustments to mechanical systems in the building because of complaints about air quality.

Canada's most-studied sick building, Les Terrasses de la Chaudière, in Hull, Quebec, is actually three linked office towers and a hotel. The complex was completed in 1977 and occupied soon after. Its sealed, energy-efficient buildings provide 1.5 million square feet of rental space, accommodating more than 6,000 workers, the vast majority of whom are federal government employees. Complaints about the air quality began soon after the building was occupied. Over the years these complaints have ranged from lack of air movement, dry skin and bad odours, to headaches, eye-nose-throat irritations, fatigue and dizziness. Even swollen ankles and toothaches have been attributed to the complex's poor-quality air.

According to Bob Davidge, chief of building performance at Public Works Canada, the federal government responded to the complaints as soon as it became clear that they were more than the usual problems associated with a new building and a recent employee move. Health and Welfare Canada conducted a series of air-quality tests in 1979. The findings showed, says Davidge, that "comfort problems specifically related to air flow and ventilation." Necessary adjustments were made and, says Davidge, the complaints decreased.

In 1981, however, several hundred office workers at Les Terrasses organized an environmental working group. The group produced flyers, buttons, even tee shirts critical of the air quality in the complex, and generally demanded remedial action. The government responded on several fronts. Internally, Public Works Canada conducted an extensive series of ventilation tests. In addition, an engineering firm was brought in to examine the complex's mechanical systems. The results, says Davidge, showed a number of basic problems: "Because of short circuiting in the ventilation system, fresh air was

being drawn into the exhaust system rather than flowing into the office. Also, thermostats had been incorrectly placed, which in turn reduced the flow of air through the variable-air-volume ventilation systems."

"Essentially," says Davidge, "we found that not enough fresh air was getting in and what was getting in often wasn't well distributed by the system." Accordingly, thermostats were moved, ducts were added and the mechanical system was re-balanced. But the complaints continued. Working with employee unions, the federal government initiated an independent investigation. Conducted by McGill University in Montreal, the study was the first large-scale examination of the health risks of poor-air quality ever done in Canada. The McGill team began its research in February, 1983 and it was completed a little more than a year later. Its findings confirmed the range of complaints at Les Terrasses, noting that they were "entirely typical of the many other episodes of 'Building Illness' or 'Tight Building Syndrome' investigated so far without satisfactory explanation in North America and Western Europe during the past decade."

The McGill study, though similarly unsuccessful in identifying the cause of the problem, suggested "that imperfect ventilation together with periods of high temperature and low humidity, could be responsible." They also noted that, since the complex was designed predominantly for open plan use, and was ventilated accordingly, "any subsequent partitioning of floor space into closed offices, or use of room dividers which interfered with free air movement, would be likely to aggravate the situation." Following the release of the report, discharge diffusers, which blow air into the offices, were again re-adjusted to allow for a better distribution of the air. And, according to Chris Reardon, P.Eng., Manager of Facilities Maintenance for Public Works Canada's National Capital Region, if necessary the room dividers may eventually be raised a few inches off the floor to further enhance the air flow through the offices.

The history of the problems at Les Terrasses, says Davidge, underlines the incompleteness of the scientists' knowledge of the Sick-Building Syndrome. "As far as basic causes go," he says, "the first thing you look for is excessive levels of contaminants. We didn't find any. Next, you look into the mechanical system to see if it's performing as designed. It wasn't. We fixed it several times, and we still got complaints." "That," says Davidge, "indicates that maybe there are important physical and psychological measures that we just aren't aware of yet."

What we do know, according to Davidge, is that some people are more sensitive than others to environmental conditions, which may account for some of the complaints. It may also be, he adds, that the international standards for building ventilation developed by the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) are simply not high enough to safely dilute all the harmful gases and particulates floating around in today's tightly sealed office buildings. (ASHRAE is now drawing up a new set of standards for building ventilation.)

Whatever the causes of Sick-Building Syndrome, Public Works' most recent measures seem to be working, according to Reardon. "The complaints," he says, "have dropped substantially."

## NO MYSTERIES HERE

Despite the confusion and uncertainty that frequently plague investigations of air quality, there are, more often than not, simple solutions to indoor air-quality problems - as this case study illustrates.

The building in question, a 14-storey commercial high rise in downtown Toronto, was built in 1964 and was not, at the time of the investigation, an energy-efficient building. The tenants' complaints, however, were in keeping with those usually associated with the Sick-Building Syndrome and ranged from headaches and fatigue to nose bleeds and irritability. Most also spoke of dry, stale-smelling air.

Engineering Interface of Toronto, an energy management consulting company, was asked to investigate the complaints. The company conducted a series of basic air-quality tests, covering temperature and relative humidity, air-flow distribution, contaminants and particulates levels and carbon dioxide readings. Carbon dioxide, while itself not a health concern, is a good indicator of the amount of fresh air in an office.

The tests showed unacceptably low humidity and high temperatures on several floors. The company also discovered foul-smelling pieces of carpet stored in an empty office on one floor. The carpet odours were seeping into the heating, ventilation and air-conditioning system. They also found an inoperative humidifier in the main air conditioning system. Further analysis revealed that one of the building's dampers had been accidentally closed, eliminating air flow to much of one floor. As well, the nozzles of the perimeter air conditioning system, which blow fan-powered cool air through the building, were plugged with fine dust - a major cause of the overly high temperatures in the building.

The problems, in short, were due not to the mysterious Sick-Building Syndrome or to any building design deficiency but to faulty building maintenance. Following removal of the rug and corrections to the building's mechanical system, including cleaning of air-conditioning supply nozzles, repair of the humidifier and re-balancing of air distribution ducts, the complaints all but stopped.

Paul O'Sullivan, an associate with Engineering Interface, says lack of proper maintenance in buildings is all too common: "A number of building owners in today's competitive office leasing market are trying to cut costs. Unfortunately, they fail to realize that preventive maintenance is cheaper in the long run."

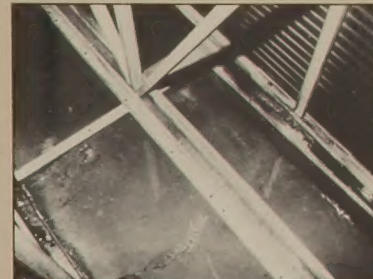
## INVASION OF THE MICRO-ORGANISMS

"Musty," "stagnant," "swamp-like." These and other words were used to describe the air on one particular floor of an office building in downtown Toronto. The 25-storey building, a typical high-rise, is equipped with sealed windows and conventional heating, ventilation and air-conditioning.

Concord Scientific, which was called in to determine the source of the odours, found normal carbon dioxide levels. And though dust levels were slightly high and temperature and humidity fluctuated, none was excessive enough to account for the complaints.

The company then brought in its microbiologist to examine the office space and the air-handling units serving the space. Surface air sampling for chemical contaminants and micro-organisms revealed nothing.

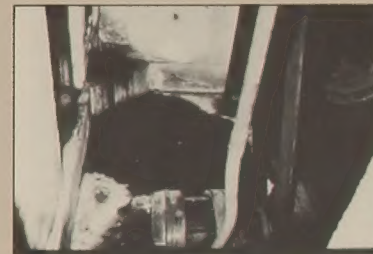
Next, swab tests of the filters and baffle plates on the air-handling units were conducted. Humidifier water in the units was also tested for micro-organisms. The results, says Concord's John Chandler, showed "bacteriological levels significantly above background levels" (38,000 cfu/ml; city water used as a control contained 650 cfu/ml).



Chandler from Concord Scientific says that everything from the simplest amoeba to more complex bacteria, moulds and fungi can flourish in reservoirs of stagnant water.

Subsequent visual inspection of the air-handling units revealed that plugged drains were preventing the system from replacing the humidifier water fast enough to prevent the growth of microbes. The humidifier nozzles were also plugged. When the units were serviced, the problem of swampy air stopped, relative humidity rose to normal and temperatures stabilized.

Chandler says that everything from the simplest amoeba to more complex bacteria, moulds and fungi can flourish in reservoirs of stagnant water. Regular inspection of these parts of the heating, ventilation and air-conditioning systems should include visual observation and microbial sampling. Muddy water, or black smudges or slimes in the water are clear indicators of a problem. Testing the water samples to ensure that the bacteria levels are similar to those in the domestic water supply will also alert building managers to potential buildups of micro-organisms.



Visual inspection of air-handling equipment can reveal potential problems. Muddy water, black smudges or slimes are obvious indicators of a problem.



Proper system design and regular maintenance can control micro-organism invasions. One way of minimizing microbial growth, Chandler says, is to vary the water temperature to create "an unfavourable habitat for micro-organisms". Another is to replace the water frequently. Chemical treatment can also work. Whatever method is chosen, the water should be tested regularly.

#### ■ IMPROVING INDOOR AIR QUALITY

Governments at both the federal and provincial levels are working on ways to minimize indoor air quality problems. At the federal level, Public Works Canada is developing new commissioning procedures to ensure that buildings owned or leased by the government are working properly before being occupied. Public Works' Bob Davidge says the process will include tests of the building's ventilation, illumination, acoustic and mechanical systems. As well, the department is developing environmental-control guidelines for building operators, which will specify the acceptable ranges for temperature, humidity, air quality and so on.

A joint Canada-United States study of the Sick-Building Syndrome is being considered, according to Doug Walkinshaw, the federal government's air quality coordinator. The proposed study, says Walkinshaw, will be the most rigorous investigation of the problem ever undertaken and will, he hopes, lead to more objective methods of recognizing and solving problems with indoor air quality.

At the provincial level, Ontario's Ministry of Government Services recently approved systems standards for new government-owned or -occupied buildings. Karl Linton, of Government Services, says that all ventilation systems in new provincial buildings will be capable of flushing out the building with fresh air when necessary. He also says that the use of conventional variable-volume systems is being reconsidered. Instead a modified system may be used that will distribute fresh air throughout the building in quantities that are never less than the minimum required for health and comfort.

Aside from government system and design initiatives, better business management, according to Concord's John Chandler will go a long way toward minimizing air-quality problems. This means, he says, that if the floor of a building is designed for 100 employees in an open space, that's the way it should be used. The all-too-common overcrowding of people and equipment or the extensive remodelling of work space, he says, strains the building's mechanical system, resulting in a variety of problems with temperature, humidity and air quality. Overcrowding and its attendant poor working conditions are more than a strain on a building's system. They also adversely affect its occupants and can lead to stress and a host of non-specific comfort and health problems - problems that can be minimized when care is taken to provide a humane working environment, one that respects both the designer's original intentions and the employees' physical and psychological needs for reasonable working conditions.

Regular systems maintenance and the careful selection of building materials and cleaning products will also reduce air pollutants, says Chandler. Furniture, carpets, space partitions and wall coverings in particular, he says, "should be chosen to minimize the amount of formaldehyde and other organic gases emitted into the office environment. Employees themselves can help," he adds, "by reducing or eliminating office smoking."

#### ■ FOR MORE INFORMATION

The Ministry of Labour investigates complaints about indoor air quality. Since 1976, over 200 complaints have been investigated. Although there are no government standards for indoor air quality, the ministry enforces a set of guidelines regarding carbon dioxide levels. The ministry was the first governmental agency to recommend the use of carbon dioxide as a marker for insufficient fresh air supply. Carbon dioxide levels above 1,000 ppm indicate an inadequate supply of fresh air. In such cases, the ministry can order building management to take whatever measures are necessary to bring the levels down below 1,000 ppm.

Carbon Dioxide (PPM)	Comments
Less than 600	Adequate fresh air.
600-800	There may be occasional complaints, particularly if the air temperature rises.
800-1000	Complaints are more prevalent
1000	Insufficient make-up air, complaints are general.

Source  
Patty's Industrial Hygiene and Toxicology, 3rd Revised Edition  
Edited by: George D. Clayton and Florence P. Clayton.

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# Airing out the Sick-Building Syndrome\*

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Canada's most-studied sick building, Les Terrasses de la Chaudière, in Hull, Québec.

\*The World Health Organization says the following are the symptoms of Sick-Building Syndrome:

Eye, nose and throat irritation; dry mucous membranes and skin erythema; mental fatigue and headache; hoarseness of voice, cough and wheezing; unspecific hypersensitivity reactions; nausea and dizziness; respiratory diseases (e.g. allergic rhinitis, asthma, hypersensitivity pneumonitis, humidifier fever, and Legionnaire's disease).



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